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REPORT OF THE NAEB STUDY ON THE PROPOSED EXPANSION OF THE MIDWEST PROGRAM ON AIRBORNE TELEVISION INSTRUCTION.

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NATIONAL ASSN. OF EDUCATIONAL BROADCASTERS

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A TECHNICAL REPORT WAS PREPARED COVERING THE IMPACT OF AIRBORNE TELEVISION TRANSMISSION ON LAND-BASED UHF TELEVISION ASSIGNMENT PLANS. THE REPORT RELATED TO THE PROPOSED EXPANSION PLANS OF THE MIDWEST PROGRAM ON AIRBORNE TELEVISION INSTRUCTION (MPATI). EARLIER STUDIES BY THE NATIONAL ASSOCIATION OF EDUCATIONAL BROADCASTERS (NAEB) HAD LED TO THE DEVELOPMENT OF COMPUTER PROGRAMS WHICH WERE USED IN PRESCRIBING A NEW UHF ASSIGNMENT TABLE. IT WAS THROUGH THE COMPUTER PROGRAM THAT THE IMPACT OF THE PROPOSED MPATI PLANS WAS DETERMINED FOR TWO STANDARDS--(1) MPATI STANDARDS, AND (2) THE ONES DEVELOPED BY NAEB ENGINEERS. IT WAS DETERMINED THAT NO FEWER THAN 60 CHANNELS WOULD BE AFFECTED IN THE MPATI PROPOSAL. UNDER THE NAEB PLAN, 33 CHANNELS WOULD BE AFFECTED. THE NAEB RECOMMENDED CONSERVATION OF AVAILABLE CHANNELS AND THE PRESERVATION OF LOCAL CONTROL OF EDUCATION. IT WAS ALSO RECOMMENDED THAT NO MASS MODIFICATION OF FCC RULES REGARDING UHF PROPAGATION AND INTERFERENCE STANDARDS BE MADE. (JC)

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NATIONAL ASSOCIATION
OF EDUCATIONAL BROADCASTERS

WASHINGTON, D.C.

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FOREWORD

The subject of this report is one of the most important and controversial topics in educational television. With large sums of money and an impressive array of well-known and competent educators in the midwest, the Midwest Program on Airborne Television Instruction has been engaged in an experimental demonstration of television instruction broadcast over a large area by transmitters in an airplane.

It is always difficult to suggest that an experiment with the scope and resources which have characterized the MPATI operation might not have been wholly successful, but that, after all, is the risk of any experiment. What has been labeled as a striking new innovation in educational television has really been an inventive way of transmitting a signal over a large area. Although the MPATI organization itself has developed helpful and useful instructional television materials, the fact that they have transmitted them from an airplane has not been their most important contribution.

The information in this report has been prepared in the hope that the strengths of the MPATI effort will continue, and that the limitations of its distribution system will be articulated and understood.

I

INTRODUCTION

A petition for rule-making was filed by the Midwest Program on Airborne Television Instruction (MPATI) on January 15, 1963, looking toward (1) the regular use of UHF channels for airborne educational television in the six-state Midwest area of Illinois, Indiana, Kentucky, Michigan, Ohio and Wisconsin; (2) the adoption of special or new engineering rules and criteria governing such airborne educational television use; and (3) the regular allocation of six specific UHF television channels for airborne educational television use in the six-state Midwest area. Comments were invited on or before January 3, 1964, and Reply Comments on or before February 3, 1964.[1/]

On October 3, 1959, Purdue University, Lafayette, Indiana, filed applications for "experimental" stations to use airborne television to provide educational programing to elementary schools, secondary schools, colleges and universities located within a radius of approximately 200 miles of Montpelier, Indiana. The major purpose of the experimental grant was to determine whether it is economically and technically feasible to make better use of

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1/ These two dates were extended to April 3, 1964 and June 3, 1964 respectively.

the television spectrum by "splitting" television channels, thereby permitting two different signals to be transmitted on a standard television broadcast channel.

As justification for the experiment, Purdue pointed to the increased enrollment expected in schools and colleges and the necessity of providing education of the highest quality to a greater number of students at the lowest possible price. Purdue maintained that a system using multi-channel airborne television held definite promise of achieving this goal, especially with a technical system to make more efficient use of the channels.

On December 22, 1959, the Commission, responding to the Purdue request, granted permission for the construction of experimental airborne television stations to operate on Channels 72 and 76. Other airborne facilities were authorized for Channels 75 and 78, and four ground-to-air facilities were authorized to use UHF channels.

The Midwest Program on Airborne Television Instruction (MPATI) started its first full academic year of the airborne program in September, 1961. From a modified DC-6 aircraft flying figure-eight patterns 23,000 feet above Montpelier, Indiana, program materials were radiated simultaneously on Channels 72 and 76 to classrooms generally within a 200-mile radius.

The television signals are broadcast by means of a 24-foot

long retractable transmitting antenna, lowered straight down from the underside of the aircraft in flight, and stabilized to maintain a vertical position. One plane is maintained on standby status while the other flies during the program day. Each has a six-man crew, three flight crew members and three television technicians.

To solve problems associated with the reception of an adequate and stable direct-to-school signal from the airborne transmitter in larger metropolitan areas such as Cleveland, Chicago, and Detroit the MPATI has used supplementary translator facilities in these cities.[2/] In order to facilitate the experiment, the FCC assigned temporary use of Channels 79 and 83 in Detroit and Chicago and 81 and 83 in Cleveland.

The following annotation from the MPATI petition for rule-making filed with the Federal Communications Commission in January, 1963, describes another type of rebroadcast situation.[3/]

> "Most schools were receiving the UHF signals direct from the airborne transmitters over equipment especially installed for the purpose. Several hundred other schools in

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[2/] Translators operate on UHF frequencies covered by Channels 70 to 83, and they are not normally used to provide a receivable signal within the main coverage of a station, but are used to provide a signal beyond the range of the main station, which they pick up with special receiving equipment and re-radiate.

[3/] "Petition for Rule-Making Submitted by Midwest Program on Airborne Television Instruction, Inc." Dr. John E. Ivey, Jr., President, pp. 1-73; Attorney for Petitioner: Percy H. Russell of Kirkland, Ellis Hodson, Chaffetz and Masters, Washington 6, D.C., January 15, 1963.

> the greater Chicago area received about half the courses over their VHF receivers via rebroadcasts from WTTW--an ETV station in Chicago. Similarly, in Columbus, Ohio, some schools that wished to use one of the courses at a time different from that scheduled from the aircraft did so via rebroadcasts from the educational station WOSU-TV."

In the engineering exhibit accompanying the petition for proposed rule-making[4/] it is proposed that the experimental operation engaged in to date be converted to a regularly licensed operation, and that a regular airborne service be established which would provide for four broadcast channels in addition to those now in use, and six ground-to-air channels. Specifically, it was proposed that six channels near the upper end of the UHF television band operate with 100 kilowatts visual ERP and 10 kilowatts aural, ERP. In its petition, the MPATI has indicated that its engineering study justifying this use is based upon new propagation curves for signal coverage which ignore certain of the FCC channel assignment "taboos" and mileage separation requirements. As a consequence, the MPATI is also asking for a change in the FCC Rules regarding interference criteria.

4/ "Engineering Exhibit-Petition for Rule-Making to Authorize the Use of Airborne Television Transmitters," T. A. Wright - A. Earl Cullum, Jr., Dallas, Texas, January 11, 1963.

II

GENERAL EDUCATIONAL AND ENGINEERING CONSIDERATIONS

For the moment, all other factors being equal, the primary problem involved in whether the Midwest Program on Airborne Television Instruction should be granted its request for expansion of service appears to a large extent to be an engineering matter. Certainly, however, the consequences of this technical problem are directly related to a number of important utilization considerations both in the schools and among potential home viewers.

The National Association of Educational Broadcasters studied both aspects of this problem, and has applied its computer developed programs to determine the extent to which additional airborne channel usage over the area covered by the MPATI eliminates ground-based UHF assignments in that part of the country. Consideration has also been given to the extent to which the participating schools actually receive the programs directly from the airplane.

It is not a simple matter to prepare a statement now which will satisfactorily report on the overall effectiveness and usefulness of airborne television instruction in the Midwest, for while on the one hand there is no question of its use by many school districts, there remain nearly 90% of the schools in the area which do not participate in the programs, and there is no indication at the moment

that these schools will automatically become participants if the airborne service is expanded. Among the school districts which do use the programs, there is no information available concerning the extent to which they are used.

All interested parties are, of course, concerned about the economic feasibility of a self-supporting airborne television system in the Midwest. Five-year proposals to schools in the area have not been accepted by the majority of them, and it is by no means certain that the funds necessary to provide continued support for the airborne operation will be forthcoming.

This report will discuss these problems in some detail because the educational and technical implications involved in airborne use of channels and their resultant impact upon a ground-based television system is of particular importance and is a matter which needs thorough discussion before the Federal Communications Commission makes a decision whether to authorize the expanded use of the MPATI operation.

Development of Co-operative Educational Techniques

There have been a number of comments about the value of programs which are distributed by the MPATI. Comments naturally range from strong endorsement to considerable doubt about the value and usefulness of the programs to a given area. At times

such comments are made about other instructional television programs, and it is not suggested that the programs which the MPATI has distributed necessarily provide any substantial basis for criticism.

One of the unique contributions which have been made by the MPATI has been in the area of instructional co-operation. The programs which have been developed and the utilization practices which have been suggested contribute to the development of co-operative instructional techniques not only across school district lines, but across several state lines. It is here that many educators and educational broadcasters have had difficult problems, and it is recognized that the MPATI has been an active force in demonstrating that such co-operative efforts are not only possible but feasible. Although the dramatic qualities of the initial airborne effort helped effect interstate educational co-operation, there is some question now about whether an airborne system three times its current size is required to maintain it, or whether such co-operation could be maintained with a ground-based interconnection system.

Reception of Instructional Television Materials

Questions regarding problems of attenuation, reflections, or other impedimenta preventing the reception of a stable and quality signal from airborne television have been answered by the suggestion

that special antennas will be used on school buildings, thus lessening such signal interference as might normally occur in standard home reception. This, of course, implies that airborne television broadcast is really point-to-point transmission and generally will not be available for home consumption.[5/]

There is an important problem involved in this suggestion, however; it is that the point-to-point aspect of school reception prevents out-of-school instruction, off-campus instruction, and other modern instructional innovations which are occurring constantly in great depth. For instance, the Chicago City Junior College could not serve its large enrollment if the signal could not be received adequately on home television receivers.

If airborne television is to make a comprehensive and significant contribution to meeting educational needs, it must be of a quality and stability that will make out-of-school, off-campus and general home reception possible for any program at any time that is equal to or better than that which could be received from land-based stations. Even if many problems associated with the reception of an airborne television signal can be resolved, the fact remains that the broadcast frequencies are being used for point-to-point transmission, from an airplane to a school building.

5/ If this is true, then it violates one of the first tenets of the FCC, i.e., that broadcast areas of the spectrum must not be used solely for point-to-point transmission.

Such inflexibility is a severe limitation to the use of these channels, partially for schools which will have added expense to receive the signals and completely for non-school uses in the home.

Utilization of the Programs in Schools

The use of television for instructional purposes is helpful to the extent that it is directly related to curriculum needs and to the ability of a teacher in the classroom to make good use of the television lessons. Because this concept has been developed and accepted slowly, it is by no means certain that simultaneous superposition of the six-channel television service on many school systems will allow television instruction to proceed at the pace at which it can best be used.

While we are not suggesting that effective use of television instruction be delayed any longer than necessary, it is also important to appreciate the pace at which change in educational procedure can reasonably be expected to proceed. The foundation grant which has supported the MPATI to this point was a terminal grant, and the future financial status of the organization is based heavily on their development of a six-channel system. In reality, therefore, the urgency of a six-channel airborne television system appears to be based more on the need for the MPATI to establish its financial structure soon than on the ability of schools to make extensive and proper use of a six-channel television service at this time.

Comments from school systems supporting the MPATI proposal have generally supported the need for more channels for television instruction. At first this would appear to indicate that schools across the Midwest are poised and ready to use airborne television as soon as six-channel service is available. But, to a large extent, the reason that many schools have supported the MPATI request, apart from having been solicited, is that more channels will allow for repetition of the telecasts and will ease their scheduling problems with a minimum of effort. On this point it has been wisely observed that a school system which cannot solve problems of class scheduling with one-channel television surely cannot be expected to handle multiple channels effectively.

The use to which the six-channel airborne service will be put is not altogether clear. Although a sample schedule has been developed by the MPATI, and submitted with its petition to the FCC, their general observation is that "the expansion will help upgrade instruction in up to 75% of the school's programs,"[6/] and the implication is that this is desirable

The extent to which this projection can be misleading is demonstrated by the long-term proposals which the MPATI is making to school systems. In the Chicago area, an attempt to develop a cooperative package over a five-year period (between the Chicago ETV

6/ Letter from John E. Ivey to William G. Harley, February 4, 1964.

stations and the MPATI) has resulted in a claim that this will be an eight-channel television service to the schools--six from the MPATI and two from the local area.

Perusal of the proposed six-channel MPATI service, however, indicates that roughly half of the time will be used for elementary schools, a quarter for college, and a quarter for secondary schools. This is by no measure a six-channel service to all schools. In fact, the six channels are useful to the MPATI primarily for ease of origination; as far as service is concerned, no schools at any level will ever be receiving a six-channel service.

An analysis of the proposed offering shows that nearly half of the time is involved in re-playing programs to provide a more flexible schedule for use in schools. This is not at all undesirable; but it is not actually a six-channel program service, and such program duplication hardly justifies the exorbitant usurpation of channels which the MPATI expansion would require.

As measured by the organization of instructional materials and the general overall quality of lessons, the MPATI has made important and helpful contributions to the effective use of television for instructional purposes. Progress thus far, however, does not point to the need for an airborne service three times more extensive, nor does the rationale for this expansion indicate

any overall readiness on the part of MPATI participants for such additional services.

What we do find is an interest on the part of MPATI members in having more channels to assist in class scheduling problems and in some instances to allow for a greater diversity of program materials.

What we do <u>not</u> find is that schools are at all aware of the impact which airborne channel usage makes on the overall ground-based channel assignment pattern in that area. From the school's point of view, the origin of the television lessons is unrelated to their value, and school support of the MPATI proposal is a support of television instruction, not a declaration that airborne transmission should be the major supplier of these materials.

Difficulty of Local Control

To give full consideration to the proposed expansion of the airborne television service, one must ponder the practical implications of a six-channel television service for many schools. It is not suggested here that six program sources are too many, but there remains a serious question about whether it is necessary or desirable for all six channels to originate from a single central source.

Persons and organizations interested in the effective use of

television materials for instructional purposes in the classroom have raised the issue of local control and local differences as it relates to the MPATI program service, for the proposal involves using public facilities not only for distributing a main program service, but it effectively eliminates these facilities for any purpose beyond the hours of the day when they will be occupied for airborne transmission.

There is no question that a six-channel television service controlled from a single point and distributed over a six-state area leaves little room for any local control, except to use or not to use the materials which are transmitted. As an advantage of the airborne system the MPATI has argued that it would take over 100 channels to provide six-channel coverage over the area theoretically covered by the airplane. What this means in terms of program control is that one organization, the MPATI, will be controlling what might otherwise be over 100 channels that could be operated on a local basis, with opportunity for local expression and service. The fact that airborne use of channels not only monopolizes the use of six television channels themselves, but prevents the use of a number of adjacent channels over a wide area makes this a particularly crucial aspect of the proposed expansion. Specific technical discussion of this matter is in Section III.

How Airborne is MPATI?

The reactions to the MPATI offerings seem to favor the television lessons themselves, but generally fail to recognize the educational and technical implications of using an airborne system which has been developed to date. Further exploration into the matter leads one to question the extent to which the entire airborne operation depends on being able to provide extended airborne service.

In a recent MPATI publication[7/] under a headline reading AIRBORNE TELEVISION INSTRUCTION IS MOVING TOWARD FULFILLMENT OF ITS POTENTIAL, the following figures appear:

> "In three short years of operation, airborne television instruction has established a practical feasibility of its concept and now is moving forward in fulfilling its potential.
>
> "Already instruction provided by MPATI is reaching an estimated 5,400 schools throughout the nation with an enrollment of more than 2,000,000 students.
>
> "About 4,200 of these schools are in the 15 major cities which lease video tapes of MPATI courses for use on local ETV stations. The other 1,200 are in the six-state region of the Midwest where schools receive the courses in telecasts from the aircraft."

A rough calculation of these figures indicates that less than one-fourth of the MPATI consumers receive the programs from

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7/ MPATI News, November-December, 1963, Vol. 2, No. 2, Page 1.

the airborne transmission. Among the 1,200 which do, not all of the schools receive the programs directly from the airplane transmission, because in Cleveland, Detroit, and Chicago, the programs are relayed by existing educational television stations and translator operations which have been established to assist in providing better reception in metropolitan areas than can be provided by the airplane's transmission. Although it is difficult to arrive at a precise figure, it is clear that less than one-fourth of the schools which are using the MPATI service are receiving the materials from the airplane transmission or an instantaneous relay of the broadcasts, and even fewer schools receive the programs directly from the airplane.

Such a situation justifies serious doubts about the need for broadcast television channels to provide the basic MPATI service. The existing airborne transmitters clearly are not being used to reach most of the schools now using MPATI programs, and additional airborne channels could at best only provide a more varied and flexible program schedule to a small percentage of schools which could receive the service directly. Any additional use of the airborne signal requires more channels in large cities where airborne reception is generally unsatisfactory.

When Efficiency is Inefficient

There have been a number of comments and two technical studies concerned with the airborne transmission of a television signal, and a number of them indicate that airborne transmission is the most efficient method for using television channels. The National Bureau of Standards is quoted as reporting that "the potential advantages of the airborne television system in spectrum efficiency and economic savings indicate that it should be exploited wherever possible."[8/]

In another study, the Westinghouse Electric Company has indicated that a "nationwide airborne system can service 99.15% of the country's 44 million students at an annual cost of 55¢ per student/per channel. A ground-based system would cost $1.53 per pupil/per channel, according to the Westinghouse study."[9/] The limitation of these studies is a practical one. For purposes of comparison, it has been assumed that: for airborne television with a six-channel service all schools in an area will be contributing to the operation of an airborne facility, because at least theoretically all of them will be able to receive the signal; for a ground-based system a lesser number of schools will participate because there cannot be enough ground-based channels to cover

8/ Broadcasting Magazine, January 20, 1964, page 68.

9/ Idem.

the same area--therefore ground-based stations will cost more to operate.

Neither the availability of 2500 megacycle systems, the use of closed-circuit, the practicality of complete airborne coverage, nor the opportunity for ground-based stations to derive funds from non-school sources was given any consideration. Both of these studies were conducted on a theoretical basis in which cost comparisons and potential usage were treated in such fashion as to have virtually no value in terms of practical operational application. They are based only on having some kind of television image on a viewer's screen, and were conducted without regard to diversity of programing, monopoly of control, and viewer accessibility.

It is important to realize that efficiency of geographical coverage is not positively correlated with educational efficiency or with efforts toward out-of-school and off-campus instruction. The fact that airborne transmission is used only a portion of the week (5 days out of 7) during a portion of the day (roughly one-third), that it is not easily received in the home, and that it effectively inhibits the growth of land-based stations which could be used at all hours of the day and for a variety of purposes cannot be considered any kind of useful efficiency.

That an airplane can fly high enough to spray a television signal over a wide area may be considered by some to be an

efficient use of a television channel. But the limitations of reception and the broad impact which such a procedure has on interference among other channels actually makes airborne transmission a relatively inefficient use of the spectrum. However efficient it appears in terms of geographical coverage, this partial and wasteful use of the spectrum, when coupled with the matter of overall control of program material over a wide area, has serious implications about the appropriateness and usefulness of program material which can be offered by an airborne system.

III

TECHNICAL FACTORS AFFECTING THE IMPACT OF AIRBORNE TRANSMISSION ON LAND-BASED TELEVISION STATIONS

(At several points in this section of the report, material is quoted from central sources. To assist in understanding the excerpt, it has been quoted in context, making some of the citations somewhat longer than usual. In several instances, the NAEB has underlined the sentences which are especially pertinent. In cases where tables or page numbers appear, these of course refer to the original document which is cited.)

In its Notice proposal for regularization and expansion of the MPATI service, the FCC listed a number of questions dealing primarily with technical concerns about the impact of an airborne television service using six channels, on ground-based channel assignments, both in the area currently covered by the MPATI and in a nationwide projection of the service.

Most of these questions dealt with the determination of reliable standards and curves which would permit calculation of the impact of airborne transmission on ground-based stations. The basis for development of these standards is included in this section of the report.

The technical standards of the Federal Communications Commission for television, and their evolution to include airborne considerations, are fundamental to this matter. In evaluating the question of standards, factors relating to signal propagation

interference considerations, taboos, field study data, translators, and UHF channel utilization must be considered. Because the knowledge gained in the past 20 years concerning television generally will be helpful as a guide in these considerations, this background is detailed in this part of the report.

Technical Background for Propagation Determinations

From Radio Technical Planning Board (RTPB) considerations beginning in 1943 through Joint Technical Advisory Committee (JTAC) efforts commencing in 1948 to study the possibilities of using UHF and a review of the entire allocations problem,[10] to 1956, television grew in various cycles. In September of that year, with VHF frequencies rapidly becoming exhausted, the FCC called a meeting of industry representatives for the purpose of expediting research and development of UHF technical operation. Subsequently the Television Allocations Study Organization (TASO) was formed with the objectives set forth as follows:

> "The objectives of this organization shall be to develop full, detailed and reliable technical information, and engineering principles based thereon concerning present and potential VHF and UHF television service."

In 1959 TASO issued its comprehensive report.[11]

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[10] "Radio Spectrum Conservation," JTAC IRE-RTMA, pp. 1-221; McGraw-Hill, 1952.

[11] "Engineering Aspects of Television Allocations," TASO Report to the FCC, pp. 1-731; March, 1959. See also Proceedings of the IRE, TASO issue, Vol. 48; June, 1960.

In January, 1960, a new Notice of Proposed Rule-Making, (identified as Docket No. 13340), was issued by the Federal Communications Commission. The Commission therein invited comment on its proposal to:

a) Consider applications for waivers of minimum television station separation in exceptional, individual cases meeting certain criteria; and

b) Adopt revised rules and standards governing calculations of the service areas of television broadcast stations.

In a further Report and Order dated August 3, 1961, in this docket case and its relationship to proposals to short space certain VHF assignments, the Commission indicated that additional VHF channels could not be secured and that it was clear that if a fully competitive nationwide television system were to be created, UHF frequencies must be utilized.[12/]

In a Notice of Proposed Rule-Making also issued August 3, 1961, the Commission established a new Docket No. 14229 consideration in the Matter of Fostering Expanded Use of UHF Television Channels. Matters such as deintermixture, short-spaced VHF assignments, relaxation of technical requirements, remote control, and ratio of visual to aural power were set forth for comment relating to expanded use of UHF channels.

12/ "Interim Policy on VHF Television Channel Assignments and Amendment of Part 3 of the Rules Concerning Television Engineering Standards, Docket No. 13340 and RM-35 -- RM-248," Pike and Fisher, 21RR1696, Paragraph 2.

On January 19, 1963, a Memorandum Opinion and Order in Docket No. 14229 and the corollary matters of deintermixture in eight cities, contained the following statement:

> "In determining service losses if existing VHF stations were required to shift to UHF channels, we were guided by the field strength charts in our present rules. These are not intended to be used to estimate the service area of an individual station, but they do provide a convenient administrative tool for comparing station coverage on a statistical probability basis. The theoretical service area of the existing VHF station was considered to extend to its Grade B contour selected from the appropriate F(50, 50) field strength chart in our present rules on the basis of the actual effective radiated power and antenna height used. The estimate of the probable UHF service area is more difficult to make. The only 'official' field strength charts available are those contained in our present rules, which are the same curves as are used to estimate the Channel 2-6 coverage. There is almost unanimous agreement that these curves are too optimistic. The T.A.S.O. group developed a set of 'critical distances' which purported to give the practical service range of UHF television stations derived empirically from field observations of picture quality. In 1956 the Commission issued a set of UHF field strength charts, commonly referred to as 'Appendix A.' There was no general agreement as to the acceptability of these curves and they were withdrawn. However, field strength measurement data obtained by T.A.S.O. closely approximated the Appendix A curves. In the absence of generally accepted curves, we used the Appendix A curves as a starting point and assumed that the UHF station would employ an effective radiated power of 500 kilowatts from an antenna about 750 feet above average terrain. Such a station was assumed to provide acceptable service for 50% of the locations 90% of the time out to a distance of approximately 40 miles, which is the highest 'critical distance' from T.A.S.O., substantially below the estimate derived from the F(50, 50) curves of our

present rules and slightly below the distance to the Grade B contour shown by the Appendix A curves."[13/]

Appendix "A" references above are generally to the document issued October 22, 1956, by the FCC Technical Research Division.[14/] This report consisting of 8 pages, 5 tables, and 15 figures was concerned with service curves, interference curves, and techniques for service calculation. Some of the material in this report which establishes one of the limits to be observed in an assessment of such allocation factors with respect to the airborne service is quoted below.

With regard to interference:

> "It was shown that, for distances greater than about 20 miles beyond the horizon, the over-all long-term time fading was substantially independent of distance and antenna height. The tropospheric fading trends versus frequency are shown in Figure 1. The top plot shows the ratio of 1% to the 10% fields, and the bottom plot shows the ratio of 10% to the 50% fields. The long-term fading distribution is approximately log-normal."

Concerning Service Contours:

> "It should be emphasized that these curves of Figures 6, 7, and 8, represent an average of many

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13/ "In the Matter of Fostering Expanded Use of UHF Television Channels in the Matters of Deintermixture of Madison, Wisconsin, etc., Docket No. 14229 and Docket Nos. 14239;14246," Pike and Fisher 21RR1725, Paragraph 6 (partial).

14/ "Propagation Data and Service Calculation Procedures Used for the Rescinded Appendix "A" of the Report and Order (Docket No. 11532) Released June 26, 1956," Fine and Taff, T.R.R. Report No. 2.4.16, Federal Communications Commission.

measurements made in all kinds of terrain. They may be termed propagation curves for typical terrain. However, the service fields over smooth terrain are expected to be greater than these curves indicate and, conversely, the service fields over rough terrain are expected to be lower than indicated by the curves. Further, the departures from the average curves will increase with frequency so that the variation at UHF will be substantially greater than at VHF."

The following considerations under the category of Techniques for Service Calculation are pertinent:

"In estimating the available rural service in the presence of noise only, the required local field intensities of the Third Notice of Further Proposed Rule Making were modified on the basis of additional data supplied by the Industry and others in response to the Commission's request for such information in Docket No. 11433, Notice of Proposed Rule Making, issued June 24, 1955, concerning the proposal to increase the maximum power for UHF stations. A good installation is assumed for describing these outer limits of acceptable rural service. As described in the previous Appendix "A," the assumed local field intensities required to overcome rural noise are 35, 44, and 53 dbu for Channels 2-6, 7-13, and 14-83, respectively. For Channels 2-6 a receiver noise figure of 6 db was assumed, for Channels 7-13 a receiver noise figure of 8 db and antenna gain improvement of 3 db were used; for the UHF a receiver noise figure of 10 db and a transmission line loss of 3 db were assumed.

"It cannot be emphasized too strongly that the propagation curves represent the average of many measurements and that under actual conditions the true signal strengths may vary from these values appreciably, especially at UHF. It should therefore be recognized that proper measurements should always be more accurate than the average curves. The techniques for computing service may be used with such measurements also, if a sufficient number are available."

A document issued by Westinghouse Electric Corporation and the Glenn L. Martin Company of Baltimore and Middle River, Maryland respectively summarized the Stratovision tests conducted on television Channel 6, 250 Mc/s, 750 Mc/s and 3300 Mc/s from December 5, 1947, to February 17, 1949.[15] This series of tests followed original airborne experiments using a smaller plane conducted from December 9, 1945, to August 30, 1946. These earlier tests were conducted on 1 Mc/s, 107.5 Mc/s and 514 Mc/s. The 1947-1949 measurements program was conducted generally with the aircraft operating at 20,000 to 30,000 feet. Measured values of field strength at a receiving location in Baltimore, Maryland, for the various frequencies over radial distances are shown on pages 300 to 331 of that report. A general range for the UHF frequencies in use today was predicted as about 200 miles for operation at 26,000 feet.[16]

Propagation factors from high antennas are considered and the following excerpts are of interest:

"3. Nulls Due to Ground Reflections.

"Figures 5-49 all show the typical interference patterns which are obtained due to alternate reinforcement and cancellation of the direct and ground-reflected waves when the transmitting and receiving antennas are high enough to allow many complete wave-lengths difference in the path lengths.

15/ "Results of Stratovision B-29 Flight Tests," Westinghouse Electric Corporation and the Glenn L. Martin Company, Baltimore, Md., 1949.

16/ Ibid, page 484.

"For example, Figure 48 shows that at 5.14 m.c., with a 30,000 foot transmitting antenna, a 30 foot receiving antenna, and 1 KW effective radiated power, a field intensity is not as strong and at three of these points, the field intensity is less than .1 MV/meter. This would be a marked disadvantage of a high transmitting antenna if it were not for the fact that the position of these nulls can be changed by changing the receiving antenna height. For example, Figure 47 shows that the null at 132 miles can be completely eliminated by reducing the receiving antenna height to 15 feet, resulting in a field intensity of 1.6 MV/meter.

"4. Co-Channel Interference.

"Figures 1 through 4 also show how the interference ranges compare for a 500 foot and a 30,000 foot transmitting antenna. At 475 megacycles, about 1.5 millivolts/meter is required for a 30 db signal-to-noise ratio, and with 25 KW effective radiated power, this is 49.5 db above microvolt/meter/KW. An interfering signal is supposed to be down 40 db to avoid co-channel interference, making the interference signal 9.5 db above 1 microvolt/meter/KW. From Figure 3 it can be seen that the service range for the 500 foot antenna is 39 miles and the interference range is 195 miles, while the service range for the 30,000 foot antenna is 220 miles and the interference range is 397 miles. Thus the service range of the 30,000 foot antenna is about 5-1/2 times that of the 500 foot antenna, while the interference range is only doubled."

Picture ghosting problems are discussed in part as follows:

"It can be seen from Figures 67-69 that the ghost amplitude gets much stronger if the reflecting object is close to either the transmitting or receiving antenna. From Figure 73 it can be seen that a reflecting object must be much further away to produce a ghost if the angle between it and the other antenna is small. From this it follows that the maximum ghost amplitude will be much less at small angles. This effect is increased

by the fact shown in Figure 70, that a reflecting object at a given distance cannot produce as strong at small angles as it can at large angles. A directional antenna, which will not respond to ghost signals, except at small angles, can reduce very substantially the maximum amplitude of ghost signals. This effect has been calculated for a few typical antennas and is plotted on Figure 74. It should be realized that to get this gain, the directional antenna must be the receiving antenna if the reflecting object is near the receiving antenna, and it must be the transmitting antenna if the reflecting object is near it. More ghost signals exist due to the reflections from near the receiving antenna, because the transmitting antenna location can be carefully chosen, but, when ghosts are caused by reflecting objects near the transmitting antenna, it is practically impossible to eliminate them, since a directional transmitting antenna cannot be used for this purpose. When the transmitting antenna is at 30,000 feet, no such ghosts will exist, because there will be no reflecting objects close enough to the transmitting antenna to cause trouble."

Problems of an airborne transmitter are discussed in Chapter II, pages 411-414. Since many items of importance are discussed therein, the material in Sections 1 and 2 is quoted in its entirety. Sections 3 and 4 discuss the transmitting antenna and airborne equipment respectively.

"1. General.

"If a television transmitter is placed in an airplane, a big advantage is immediately gained because of the increased antenna height. At the same time, however, many new problems are introduced which must be considered before it can be determined whether the idea is practical.

"2. Effect of Aircraft Motion.

"An airplane cannot remain motionless with respect to the ground unless its air speed is equal and

opposite to the wind velocity. While high wind velocities are quite common at high altitudes, they are not nearly consistent enough that they may be depended upon, and it is necessary to specify a circle of some fixed diameter within which the plane will stay, rather than specifying a fixed location as can be done for a ground station.

"This immediately reduces the maximum range of the station by a distance equal to the radius of this circle, since at some point in its circle the plane will be that much further from a distant point, and usable signal during part of the cycle would not be much help.

"The interference range of the station is at the same time increased by the radius of the circle, since at another point on its circle the plane will be that much closer to a distant point.

"Both of these effects are serious enough that they must be considered in determining the service area and interference area of an airborne station, but the size of the plane's circle can be kept small enough compared to the maximum range of the transmitter that the statements previously made concerning the increased service range and increased ratio of service area to interference area for a high antenna are not markedly changed.

"Figure 74 shows the minimum size circle which a plane flying 145 m.p.h. can stay inside of for various wind velocities and angles of bank. Two sets of curves are included. Those in which the diameter of the circle increases with increasing wind velocity are for a course in which the plane continually circles in one direction, flying in a straight line against the wind after each circle for the time required to return the distance the wind carries it during the circle. As the wind velocity increases, the wind carries the plane further as it circles, thus increasing the maximum dimension of the course. For high wind velocities, the plane can stay inside a smaller circle by flying continuously into the wind, banking first to the right and then to the left just enough to keep the average forward velocity of the plane equal to the wind velocity.

This course gets smaller as the wind velocity increases, reaching a point when the wind velocity equals the plane velocity. The second set of curves applies to this type of course.

"If the velocity of the plane is increased, the size of the circle is increased for the same angle of bank. Since small angles of bank are desirable for a practical transmitting antenna, a slow plane is helpful in maintaining a small diameter circle.

"The size of circle given by Fig. 74 is that which is required theoretically. In practice, a larger circle will be needed to take care of variations from the theoretical course. How much it is necessary to add for this factor will depend on how well informed the pilot is of his position. With low wind velocities, a pilot could keep pretty close to the theoretical course with aid of a standard radio beacon with a fan marker, by following the beacon until his indicator showed him to be over the fan marker, and then making a full 360 degree circle, straightening out twice during the circle, once when heading into the wind to compensate for his drift during the circle, and once at the 180 degree point to assure his getting back on the beacon before reaching the fan marker, which would give him time before the next circle to make any necessary corrections. With higher wind velocities, the error in such a system would become more serious, so that it would be necessary to either provide a better means of maintaining the course or to allow for substantial deviations from the theoretical course.

"It is feasible to design an automatic pilot system which would cause a plane to follow fairly accurately either of the theoretical courses which have been described provided the proper wind velocity and direction were fed into it. It also seems entirely possible that a practical system could be devised which would determine drift from radio markers of some sort and use this information to feed corrections into such an automatic pilot to keep the plane close to the theoretical course automatically and indefinitely.

"Even though a receiving location may receive sufficient signal for a usable picture during the entire circle of the airplane, the signal may vary enough during the cycle to be objectionable. Figures 5-49 show that, if no nulls are encountered, the signal strength can vary by two or three to one for each 10 mile motion of the plane in the VHF television band, while in the UHF band, the ratio can become as high as five to one. For receivers which are not located too far away from the plane, this ratio can be minimized by adjusting the height of the receiving antenna so that the operating point is in the flat-topped region between two nulls, preferably the two most distant nulls. For receivers very close to the plane where such an arrangement would result in an impractically low antenna, an antenna with some vertical directivity can be used, pointed up to discriminate against the ground-reflected wave. For receivers located near the maximum range of the transmitter, no practical antenna will prevent the variation. The variation occurs quite slowly, since it takes the plane several minutes to make a circle and much larger variations can occur without being objectionable than would be the case with rapid variations. Experience has shown that at Channel 6 (82-88 m.c.) the effect is bad enough to make the picture unusable. In the UHF band, however, the effect would probably be enough worse that the picture could not be used without AGC circuits in receivers. Most present-day receivers have such circuits.

The direction of the airplane will also have an effect on the ghosts which are received. The effect may be either a change in amplitude or a change in position of the ghost. Figs. 76-78 show the change in path difference as the plane moves around in a 20 mile diameter circle. It can be seen from these curves that for a majority of the ghosts, where the distance from the receiving antenna to the reflecting object is a fraction of a mile, the motion will be quite small. (1 microsecond delay time represents about 1.60 of the width of the picture.) Even when the ghosts move in the order of 20 microseconds, however, which is about as large a motion as is likely to

occur, it is believed that the slow rate at which the motion occurs will make the moving ghost no more objectionable than a stationary one. Figs. 67-70 show that the maximum amplitude of a ghost changes very little for changes in distance to the plane, but that the maximum amplitude may change appreciably for sidewise motion of the plane, which causes phase to vary. Even larger changes in amplitude, may be caused by the fact that a reflecting object may be oriented to give the maximum possible ghost signal for one position of the plane and be oriented wrong for a different position of the plane. This effect will be greater for high frequencies and large reflecting objects. In the UHF television band (475 to 890 m.c.), if a 3 ft. parabolic receiving antenna is used, any object large enough to produce a ghost will produce a sharp enough beam that the motion of the plane will cause a very substantial change in the amplitude of the ghost. Because of this, there is an appreciably greater chance of getting an objectionable ghost at some point in the plane's circle than would be the case with a fixed transmitting antenna at the same height. However, Fig. 74 shows that if a 3 ft. parabolic receiving antenna and a non-directional transmitting antenna need be only 1/40 to 1/100 the size of an object near the receiving antenna to cause an objectionable ghost. Because of this, it is felt that the greater number of objectionable ghosts which will occur due to objects near the receiving antenna for a STRATOVISION system, will be more than offset by the elimination of objectionable ghosts due to objects near the transmitting antenna, when the antenna is raised away from all nearby objects."

Many of these factors are brought up to date in the "Petition for Rule-Making submitted by Midwest Program on Airborne Television Instruction Inc.," and the accompanying "Engineering Exhibit - Petition for Rule-Making to Authorize the Use of Airborne Television Transmitters." Additional assumptions are made with respect to the potential and existing operational effects observed since operations under MPATI commenced in 1959.

The National Bureau of Standards has also undertaken calculations[17] and measurements[18] with respect to the MPATI program. The conclusions from the Decker study, although preliminary, indicate that the system will require the use of carefully designed equipment with maximum possible transmitter power and lowest possible receiver noise figures. Commercial UHF-TV receiving sets listed as currently available in the TASO report are probably not adequate for this system.

The conclusions of the NBS report suggest the possibility of atmospheric effects which may be pertinent in coverage analysis and standards considerations. Propagation anomalies which result from atmospheric refraction of radio waves have been observed in airborne propagation at 250-10,000 Mc/s.[19] The additional work being undertaken by NBS should be helpful in further definition based upon the recordings program, but there is no conclusive data on this subject at this time, and continued airborne transmission would have to be considered experimental.

17/ "Service Area of an Airborne Television Station," M. T. Decker, NBS Technical Note, No. 35, Boulder Laboratories, October, 1959.

18/ "National Bureau of Standards Measurement Program on UHF Airborne Television," R. S. Kirby, A. P. Barsis, and P. L. McQuate, NBS Report 7274, June 30, 1962. (Permission must be obtained from NBS to refer to this report.)

19/ "Refraction Anomalies in Airborne Propagation," Mong S. Wong, Proceedings of the IRE, pp. 1628-1638, September, 1958.

IV

THE IMPACT OF MPATI AIRBORNE TRANSMISSION ON LAND-BASED UHF BROADCAST TELEVISION FACILITIES

Determination of Standards for Evaluation

The airborne operations proposed by the MPATI will cause interference to ground-based stations; until now, what has not been known is the nature and extent of this interference. Co-channel and adjacent channel interference is acknowledged by the MPATI, but, in addition, certain other interference possibilities, such as those arising from operation on "image" frequencies, must be considered.

The range within which ground stations would be affected by the various types of interference depends upon assumptions regarding propagation and desired-to-undesired signal ratios. These factors will be discussed below. In addition, once the tools for calculating interference are at hand, it is necessary to decide what degree of interference, if any, is permissible; and this, in turn, requires a decision as to the facilities with which it is assumed a ground station will operate.

To take the latter factor first, it seems reasonable to assume land-based operations with an effective radiated power of 500 kilowatts and an average effective antenna height of 1,000 feet. This level of effective radiated power can be obtained with an antenna

having a power gain of approximately 25 and a 25-kilowatt transmitter. The 25-gain antenna provides a desirable concentration of the radiated signal without compressing the beam-width below acceptable limits. The 25-kilowatt transmitter, at the present time and for the foreseeable future, appears to be the upper limit of that which is economically feasible and is practical in a community of average size.

This same rationale is equally applicable to an effective antenna height of 1,000 feet. Throughout much of the area which would be affected by the proposed MPATI operation, the effective antenna height would not differ materially from the height of the supporting tower. Aside from economic factors, consideration also must be given to potential aeronautical hazard problems, which would undoubtedly arise if structures appreciably taller than 1,000 feet were to be considered standard antenna height.

With regard to the question of the extent to which interference is tolerable, it may be observed that two ground stations operating on the same channel with the facilities assumed above will cause interference to each other when they are located 155 miles apart. (This statement anticipates assumptions regarding propagation and desired-to-undesired signal ratios which are discussed below.) It would seem reasonable to permit an airborne station to cause interference to a ground station in approximately the same degree.

Accordingly, the following studies are predicated on the assumption that this degree of interference is permissible.

Propagation Curves

The propagation curves for Channels 14 through 83 which are contained in the FCC Rules are not appropriate for use in predicting service and interference from an airborne operation. The MPATI has developed curves which it proposes for use in making these determinations; in addition, it has curves for ground stations which are suggested for use in evaluating the effects of airborne transmission. The latter curves, when compared to those in the FCC Rules, show a significantly different distribution of field strength within the service area of a UHF station (bounded by the 64 dbu contour) and an increase in the service radius.

It is not known whether the propagation curves proposed by the MPATI provide a sound basis for estimating the impact of air-

theoretical considerations, and, from this standpoint, they represent a reasonable estimate of the propagation characteristics to be expected. It must be emphasized, however, that only a very limited amount of measured data is available which could serve to substantiate these curves. Thus, while they have been used to estimate the interference caused by the proposed airborne operation

to ground stations, it should be understood that this assessment can by no means be regarded as definitive.

The curves proposed by the MPATI for ground stations are found by NAEB engineers to exhibit characteristics with regard to the extent of service area and the magnitude of signals available within the service area which have not yet been proved by field measurements. It is held that a more realistic estimate of these factors is provided by the curves in the FCC Rules. It might be noted that experience with field strength surveys tends to show that in certain circumstances even the latter curves are somewhat optimistic.

In calculating the interference between ground-based stations, use was made of the F(50, 10) curves which are presented in the FCC Technical Research Report 2.4.16.

The television rules of the FCC recognize a number of types of interference between UHF stations and precautions are taken through allocation procedures to avoid or minimize such interference. The requirements of the Rules are summarized in the following table:

Table 1

FCC MILEAGE SEPARATION RULES FOR
LAND-BASED UHF BROADCAST STATIONS

TYPE OF INTERFERENCE	CHANNEL SEPARATION	REQUIRED MINIMUM MILEAGE SEPARATION
Co-channel	0	155 miles[1/]
Adjacent Channel	± 1	55
Intermodulation	± 2, 3, 4, 5	20
Oscillator Radiation	± 7	60
I. F. Beat	± 7, 8	20
Sound Image	±14	60
Picture Image	±15	75

1/ Zone 1

Co-Channel Interference

The MPATI has proposed that a separation of 290 miles be required between the proposed airborne operations and ground stations operating on the same channels. The MPATI assumption is that ground stations would operate with an effective radiated power of 1000 kilowatts and an effective antenna height of 2,000 feet, thereby providing a stronger signal less subject to airborne interference. The 290-mile separation which they propose, therefore, would produce interference equivalent to that which would be permitted

by one such ground station to another. The calculations which underlie this proposal were made using the propagation curves which are recommended in the MPATI petition to the FCC.

NAEB calculations, based on the different assumptions and propagation curves concerning transmitter power and antenna height previously discussed, indicate that the co-channel separation between airborne and land-based stations should be increased to 320 miles if the interference is to be held to a level equivalent to that which would be caused by a ground station. Here, as in the case of the MPATI calculations, the interference determinations are actually made from a point 10 miles closer to the assumed ground station so as to take into account the orbital excursions of the aircraft.

In both cases, a desired-to-undesired signal ratio of 28 db has been used. This ratio is generally accepted as being valid for offset carrier operation. It might be noted that a ratio of 45 db is required when the carriers are not offset. While it should not be difficult to provide for offset carrier operation in the case of those stations located just beyond the minimum co-channel separation, some assignments in the next ring would probably operate with the same carrier frequency assignment as the airborne operation. It is quite likely that interference problems could arise out of this situation. The propagation data available do not provide

an adequate basis for a definite judgment in this regard.

Adjacent Channel Interference

The MPATI suggests that the adjacent channel separation requirement be set at 200 miles. Our studies indicate that this separation would probably be adequate. There is no generally accepted desired-to-undesired signal ratio for the determination of adjacent channel interference; if, however, a ratio of approximately -10 db were to be assumed, the 200-mile separation would provide protection equivalent to that obtained with a 320-mile co-channel separation.

Intermodulation, Oscillator Radiation and I.F. Beat Interference

It is believed that, as the MPATI suggests, these potential sources of interference could be eliminated from consideration insofar as an airborne system is concerned. It must be emphasized, however, that the elimination of oscillator radiation interference rests on the assumption that airborne transmissions would be received only in schools or other places with specially-equipped receivers. The assumption is a workable one, but elimination of this type of interference is not consistent with effective reception of an airborne signal under normal circumstances. Granting of this assumption re-emphasizes the point-to-point nature of the airborne signal, and

curtails any kind of general home reception of MPATI in most areas.

Picture and Sound Image Interference

The MPATI states that these sources of interference may also be eliminated from consideration. The FCC, however, in its notice of rule-making in this proceeding, indicates that some degree of protection would be necessary if the normal service area of a ground station is to remain unimpaired.

There is a wide divergence of views regarding the desired-to-undesired signal ratio or ratios which should be used to calculate this type of interference. The MPATI suggests ratios of -4 db and -20 db for the determination of picture and sound image interference respectively. The Commission states that a ratio of 0 db or 10 db is necessary to avoid picture image interference. It states further that in the case of sound image interference protection for color reception would require about the same separation as would be required for picture image protection.

The NAEB study of the impact of airborne transmission has been conducted using the ratio of -4 db suggested by the MPATI. It was found that a separation of 260 miles would be required if picture and sound image interference is to be held to the equivalent of that which would be tolerated from a co-channel operation.

Impact of the MPATI Proposal on the FCC and NAEB Assignment Plans

The expansion of the MPATI's airborne transmission will cause interference to land-based stations. If this interference is based on new standards which the MPATI suggests are more appropriate and realistic, the number of existing stations and proposed assignments which will be affected is considerably less than when the interference is based on standards and curves used by the FCC. The NAEB has studied the impact of airborne interference using these two different standards on its own proposed UHF Table of Assignments. It has been possible to indicate the specific assignments which would be deleted as well as a small number of communities to which other channels could be assigned. The FCC has conducted a similar study of its own proposed plan, and has indicated its findings in its Notice of Proposed Rule-Making, in Docket 15201, October 24, 1963.

Impact of MPATI Proposal on the Proposed FCC Plan

> "If we accept the MPATI assumption that we need to be concerned only with co-channel and adjacent channel separations, 15 of the assignments proposed in the new UHF Table would not meet the proposed 290-mile co-channel separation and 17 would fail to meet the proposed 200-mile adjacent channel separation requirement. We have proposed the reservation of eight of these channels for educational use. In addition, 4

assignments which Canada has recently assigned in the Province of Ontario fall short of the required co-channel separation."[20]

With respect to picture and sound image interference, the FCC Notice has pointed out:

> "Since the MPATI receivers will be operating in the upper end of the UHF television band, receivers tuned to their signals will not be exposed to potential 'image' interference due to the operation of the MPATI transmitters. Such interference is most likely to occur in the weaker signal areas of the ground-based television stations which are located within or near the service area of the airborne stations. If interference is to be avoided, the signal from an airborne station operating on the fifteenth channel above the one to which a television receiver is tuned cannot exceed a level equal to, or in some cases 10 decibels weaker than the desired signal. In order to protect the normal service area of a ground-based television station operating with 1/2 megawatt of power from an antenna 1,000 feet above average terrain, the airborne station flying at 23,000 feet and radiating 100 kilowatts would have to be about 200 miles away. While somewhat shorter separation could be tolerated with respect to the sound image (fourteenth channel above the desired channel) for monochrome reception, protection for color reception would require about the same separation as the picture image protection.
>
> "If the above assumptions are correct, ground-based television stations would not be operated within the service area of the airborne stations without having impaired coverage due to 'image' interference. This would require deletion of assignments in 30 additional places proposed in the new Table, or, if assignments were made in spite of the 'image' interference problem,

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[20] Specific assignments which are affected are listed in the appendix of the FCC's Notice of Proposed Rule-Making, Docket No. 15201, October 24, 1963.

30 stations would suffer impaired coverage due to interference."[21]

The FCC also referred to the general problem of UHF translators in the MPATI area and nearby:

> "Also to be considered is the possible impact of the proposal on the UHF translator service, wherein stations operate on Channels 70 and above. The Midwest states which MPATI proposed to serve are not the portion of the nation where this service is most used; but within these six states there are at least two translators authorized within 290 miles of Montpelier, Indiana, on channels MPATI seeks, and another on an adjacent channel within 200 miles. Two additional translators are authorized in western Pennsylvania on channels MPATI would use, within the 290-mile radius. With respect to these, and other translators which may be authorized within this area, obviously interference considerations might exist. Furthermore, the Commission indicated in the initial Notice in Docket No. 14229 that we anticipated that UHF translators would be used to provide more uniform coverage by UHF stations. The efforts which we are making to foster the expanded use of the UHF channels could be hampered if prospective UHF broadcasters in the MPATI area were precluded from using UHF translators."

Impact of the MPATI Proposal on the Proposed NAEB UHF Assignment Plan

The NAEB has conducted two studies designed to use the computer program which was devised to develop the UHF assignment table which the NAEB submitted to the FCC in November, 1963.[22]

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[21] Specific assignments which are affected are listed in the appendix of the FCC's Notice of Proposed Rule-Making, Docket 15201, October 24, 1963.

[22] NAEB, UHF TELEVISION ASSIGNMENT PLAN, Washington, D.C., 1963.

The speed of the computer and accessibility of appropriate data in the computer program made it practical to determine the impact of the proposed MPATI expansion in two different contexts. One was by using new standards which MPATI recommends for calculating interference and determining UHF propagation characteristics, and the second by using standards developed by NAEB engineers.

First, the computer was programed to print out the location and channel number of assignments which would have to be deleted if MPATI propagation curves were adopted. These data are listed in Table 2. New assignments which could be added to the Table of Allocations to replace those which had to be deleted are noted in Table 3.

Table 2

ASSIGNMENTS IN THE NAEB UHF ASSIGNMENT TABLE WHICH MUST BE DELETED BECAUSE OF INTERFERENCE FROM MPATI TRANSMISSION (BASED ON MPATI INTERFERENCE STANDARDS)23/

	Channel	City
1.	76	Alton, Illinois
2.	78	Belleville, Illinois
3.	73	Decatur, Illinois
4.	74	Joliet, Illinois
5.	71	Mattoon, Illinois
6.	72	Monmouth, Illinois
7.	83	Normal, Illinois
8.	79	Ottowa, Illinois
9.	75	Rantoul, Illinois
10.	80	Rockford, Illinois

23/ 290 Mile co-channel separation and 200 mile adjacent channel separation. No allowance for picture and sound image interference.

Table 2 (cont'd)

	Channel	City
11.	82	Springfield, Illinois
12.	76	Waukegan, Illinois
13.	80	Anderson, Indiana
14.	82	Columbus, Indiana
15.	80	Evansville, Indiana
16.	82	Hammond, Indiana
17.	76	Hartford City, Indiana
18.	77	Indianapolis, Indiana
19.	78	Logansport, Indiana
20.	81	Terre Haute, Indiana
21.	72	Washington, Indiana
22.	76	Cynthiana, Kentucky
23.	81	Frankfort, Kentucky
24.	83	Louisville, Kentucky
25.	73	Louisville, Kentucky
26.	72	Maysville, Kentucky
27.	76	Middlesboro, Kentucky
28.	83	Benton Harbor, Michigan
29.	77	Benton Harbor, Michigan
30.	76	Detroit, Michigan
31.	73	Flint, Michigan
32.	75	Grand Rapids, Michigan
33.	72	Kalamazoo, Michigan
34.	79	Owosso, Michigan
35.	76	Athens, Ohio
36.	75	Bellefontaine, Ohio
37.	77	Coshocton, Ohio
38.	81	Fostoria, Ohio
39.	71	Greenville, Ohio
40.	83	Marion, Ohio
41.	80	Newark, Ohio
42.	78	Sandusky, Ohio
43.	79	Springfield, Ohio
44.	78	Clarksburg, West Virginia
45.	72	Fairmont, West Virginia
46.	72	Madison, Wisconsin
47.	74	Chatham (Canada)
48.	80	Chatham (Canada)
49.	82	Leamington (Canada)
50.	72	Sarnia (Canada)

Table 3

REPLACEMENT ASSIGNMENTS FOR ASSIGNMENTS DELETED BECAUSE OF INTERFERENCE FROM MPATI BASED ON MPATI INTERFERENCE STANDARDS

Channel 83 Assigned to Alton, Illinois
Channel 79 Assigned to Belleville, Illinois
Channel 81 Assigned to Evansville, Indiana
Channel 77 Assigned to Clarksburg, West Virginia

Next, using standards which the NAEB considers to be appropriate, the computer was programed to calculate which assignments in the proposed NAEB UHF Assignment Table would be deleted because of interference from MPATI Airborne transmission. These assignments and their locations are listed in Table 4. The assignments which could be added to the NAEB Table of Allocations to replace those which had to be deleted are listed in Table 5.

Table 4

ASSIGNMENTS IN THE NAEB UHF ASSIGNMENT TABLE DELETED BECAUSE OF INTERFERENCE FROM MPATI TRANSMISSION (BASED ON NAEB INTERFERENCE STANDARDS)[24]

	Channel	City
1.	76	Alton, Illinois
2.	78	Belleville, Illinois
3.	62	Bloomington, Illinois
4.	57	Centralia, Illinois
5.	65	Champaign-Urbana, Illinois

[24] 320 mile co-channel separation and 200 mile adjacent channel separation picture and sound image interference requiring 260 mile separation.

Table 4 (cont'd)

	Channel	City
6.	73	Decatur, Illinois
7.	63	DeKalb, Illinois
8.	58	Dixon, Illinois
9.	74	Joliet, Illinois
10.	71	Mattoon, Illinois
11.	72	Monmouth, Illinois
12.	69	Newton, Illinois
13.	83	Normal, Illinois
14.	79	Ottowa, Illinois
15.	75	Rantoul, Illinois
16.	80	Rockford, Illinois
17.	64	Springfield, Illinois
18.	82	Springfield, Illinois
19.	76	Waukegan, Illinois
20.	80	Anderson, Indiana
21.	62	Columbus, Indiana
22.	60	Evansville, Indiana
23.	68	Fort Wayne-Roanoke, Indiana
24.	60	Frankfort, Indiana
25.	66	Gary, Indiana
26.	82	Hammond, Indiana
27.	76	Hartford City, Indiana
28.	57	Indianapolis, Indiana
29.	77	Indianapolis, Indiana
30.	78	Logansport, Indiana
31.	64	Madison, Indiana
32.	58	Peru, Indiana
33.	61	South Bend, Indiana
34.	63	Terre Haute, Indiana
35.	81	Terre Haute, Indiana
36.	72	Washington, Indiana
37.	78	Cynthiana, Kentucky
38.	67	Elizabethtown, Kentucky
39.	81	Frankfort, Kentucky
40.	57	Glasgow, Kentucky
41.	60	Lexington, Kentucky
42.	83	Louisville, Kentucky
43.	62	Louisville, Kentucky
44.	73	Louisville, Kentucky
45.	72	Maysville, Kentucky
46.	76	Middlesboro, Kentucky

Table 4 (cont'd)

	Channel	City
47.	63	Pikeville, Kentucky
48.	60	Ann Arbor, Michigan
49.	63	Benton Harbor, Michigan
50.	77	Benton Harbor, Michigan
51.	76	Detroit, Michigan
52.	73	Flint, Michigan
53.	63	Grand Rapids, Michigan
54.	75	Grand Rapids, Michigan
55.	72	Kalamazoo, Michigan
56.	60	Manistee, Michigan
57.	61	Midland, Michigan
58.	79	Owosso, Michigan
59.	67	Saginaw, Michigan
60.	76	Athens, Ohio
61.	75	Bellefontaine, Ohio
62.	59	Bowling Green, Ohio
63.	61	Canton, Ohio
64.	67	Chillicothe, Ohio
65.	61	Cincinnati, Ohio
66.	77	Coshocton, Ohio
67.	64	Defiance, Ohio
68.	81	Fostoria, Ohio
69.	71	Greenville, Ohio
70.	62	Lima, Ohio
71.	57	Lorain, Ohio
72.	68	Marietta, Ohio
73.	83	Marion, Ohio
74.	80	Newark, Ohio
75.	78	Sandusky, Ohio
76.	79	Springfield, Ohio
77.	66	Springfield, Ohio
78.	65	Tiffin, Ohio
79.	67	Warren, Ohio
80.	58	Zanesville, Ohio
81.	74	Indiana, Pennsylvania
82.	74	Cookeville, Tennessee
83.	72	Charleston, West Virginia
84.	78	Clarksburg, West Virginia
85.	72	Fairmont, West Virginia
86.	65	Huntington, West Virginia
87.	67	Janesville, Wisconsin

Table 4 (cont'd)

	Channel	City
88.	64	Kenosha, Wisconsin
89.	72	Madison, Wisconsin
90.	59	Milwaukee, Wisconsin
91.	68	Sheboygan, Wisconsin
92.	74	Chatham (Canada)
93.	80	Chatham (Canada)
94.	82	Leamington (Canada)
95.	72	Sarnia (Canada)

Table 5

REPLACEMENT ASSIGNMENTS FOR ASSIGNMENTS DELETED BECAUSE OF INTERFERENCE FROM MPATI BASED ON NAEB STANDARDS

Channel 82 Assigned to Alton, Illinois
Channel 79 Assigned to Belleville, Illinois
Channel 71 Assigned to Centralia, Illinois
Channel 73 Assigned to DeKalb, Illinois
Channel 81 Assigned to Evansville, Indiana
Channel 73 Assigned to Glasgow, Kentucky
Channel 73 Assigned to Manistee, Michigan
Channel 79 Assigned to Midland, Michigan
Channel 77 Assigned to Canton, Ohio
Channel 77 Assigned to Charleston, West Virginia
Channel 79 Assigned to Huntington, West Virginia
Channel 75 Assigned to Milwaukee, Wisconsin

Summary of the Impact of MPATI Airborne Transmission on Land-Based UHF Broadcast Television Stations

To a large extent, Tables 2-5 tell their own story. If the MPATI proposal for expansion were approved, and six airborne channels on 72, 74, 76, 78, 80 and 82 were authorized to operate on a

regular basis, 62 channel assignments in the FCC's proposed plan would need to be deleted or would operate with interference brought about by the airborne operation. In the proposed NAEB plan, 83 assignments would be affected. Even using the standards which are proposed by MPATI the use of these six airborne channels would require the deletion of at least 46 proposed assignments.

The natural response to this, of course, is to suggest that many of the assignments in the FCC plan and the NAEB plan are unnecessary. Even if this were true, it would be true only for the immediate present. Arguments to the effect that communities must be a certain size, say, 50,000 population, before an unreserved assignment should be made are not convincing in the view of the need to consider metropolitan area populations, market size and the fact that the average population growth in urban areas of this country is nearly 30%.

Currently in the 83 communities where assignments in the NAEB plan would need to be deleted, there are 53 communities whose population is under 50,000. Among these communities, over 25% have shown a population growth of more than 20% in the past ten years, and over 50% have grown more than 10%. A land-based television channel assignment plan must consider these factors and any effort to minimize the impact of airborne transmissions by categorically reducing the number of land-based assignments is short-lived and simply postpones a face-to-face encounter with the problem.

V.

OTHER TECHNICAL CONSIDERATIONS

In its Notice of Proposed Rule-Making (Docket No. 15201) the FCC raised a number of questions which are related to the proposed expansion of the Midwest Program on Airborne Television Instruction. These involve technical issues which are only indirectly related to the major focus of this study, so they are reviewed briefly in this section of the report.

Feasibility of Operation

The question of whether six television broadcast channels can be transmitted from a single airplane has not been answered. The two main alternatives are (1) the use of two airplanes, each with three transmitters and three antennas, following each other through the 10-mile orbit, or (2) the use of a larger airplane in which six transmitters and six antennas may be able to be mounted. Speculation is that either of these alternatives could be worked out, but neither has been specifically proposed and it is uncertain which, if either, would be actually successful.

If two planes are used for the six-channel transmission, the possibility of a standby airplane will be eliminated, unless a third and/or fourth plane is required as part of the operation. It would

not seem reasonable to undertake such an operation without some kind of standby aircraft and transmission equipment, and tl is would, of course, increase costs considerably.

It is important to realize, too, that in either event, the six-channel system will involve the use of additional frequencies and equipment to relay the signal from the ground to the airplane where it will be received and then be broadcast. No doubt this, too, can be made to work, although it will be experimental for some time and does involve the use of more frequencies.

Lack of Coverage Directly Beneath the Aircraft

Within a 40-mile diameter directly underneath the airplane, reception is unsatisfactory, although both the MPATI and Westinghouse report that considerable effort has been devoted to the solution of this problem. There are some possibilities for eliminating this reception difficulty, however, but as Westinghouse Corporation has indicated, "an adequate solution to this problem is not yet known at present."[25/] It is argued that the 40-mile area is relatively unimportant because the aircraft would normally be located over sparsely populated areas while it is orbiting; however, one of the arguments for airborne transmission of course is that it is able

25/ Westinghouse Electric Corporation, "Educational Television Distribution," Baltimore, Maryland. July, 1963. pp. 1-42.

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to cover sparsely populated areas that cannot be covered by ground station. There does not appear to be a satisfactory solution to this difficulty right at the moment.

Ground-Reflected Signal Cancellation

In the case of airborne transmission, because distance between the receiving antenna and the transmitting antenna varies, strong fluctuations occur. The problem is particularly severe in flat terrain where the signal fluctuation is accompanied by a reflected signal from the ground or from large bodies of water. The customary solution is to locate the receiving antenna at a minimum height that provides an adequate signal. However, in a number of cases, it is necessary to use height diversity reception, that is, the use of two antennae at different heights. With proper spacing and phasing, signal fluctuations can be reduced, though not eliminated. Although MPATI engineers emphasize that most of these problems can be solved, the cost, time, and effort which will be required to provide adequate signals to normal school installations are an extra factor which must be considered that will add to the question of efficiency, feasibility, and practicability of providing a stable, quality signal.

Translators in Metropolitan Areas

The current MPATI operation involves not only the use of two UHF channels for general broadcast throughout the Midwest, but the additional use of UHF channels, as translators, in Detroit, Cleveland, and Chicago. In a six-channel operation, this would increase three-fold the number of UHF channels involved; however, there is now discussion which suggests the appropriateness of the 2500-megacycle frequencies as a "translator" device in these areas. It is likely that this would work, although propagation characteristics on these frequencies may pose problems, particularly with regard to the extent of coverage which are not currently anticipated.

If that suggestion is pursued, it does involve a complete conversion of receiving equipment in schools which are now attempting to receive a UHF signal either directly from the airplane or from a translator. Inasmuch as this is a new effort to solve an old problem, it is unlikely that schools are aware of the additional expense which would be encountered. Both the time and costs which grow out of this solution demonstrate again that what is labeled "efficient" is really not. For the moment, at least, a six-channel service would in all likelihood involve the use of the 2500-megacycle band in large metropolitan areas and there would be no way to avoid these added costs.

2500-Megacycle Band for Air-Ground Transmission

The FCC Notice asked for comments regarding the feasibility of using the 2500-megacycle frequencies for air to ground transmission. The information on this possibility is not fully documented, and experimentation of airborne use of these frequencies is needed to identify the practical differences between the use and reception of frequencies in the UHF band and those at 2500-megacycles.

Nationwide Implications

The Midwest Program on Airborne Television Instruction has requested only that six channels be allocated for the Midwest area. The implication of this request, however, is that if the system is desirable for the Midwest, it certainly should have application elsewhere. But, will the application be made on a state-by-state basis? On a regional basis, and if so, what regions? Or, on a nationwide grid basis, such as proposed by Westinghouse? Some uniform system would be necessary, for airborne transmission does not lend itself to a combination of different operational patterns.

No matter which system might be used, the impact upon local educational control and the use of 15-18 channels across the country for a limited portion of the day for a small percentage of schools

prophesy problems of enormous proportions. If it were worth the costs, which until now no one has faced squarely with regard to capital outlay, operating expenses, or depletion of technical resources, there would be reason to support the limited MPATI proposal and even its natural expansion to the nation. Information available to date indicates that this is not a wise and thoughtful policy to meet educational needs in a practical and feasible way.

VI

SUMMARY AND RECOMMENDATIONS

Careful study of the educational and technical factors which are pertinent to the request of the Midwest Program on Airborne Television Instruction for an expanded and regularized service leads to the conclusion that what is given away for what is obtained is an unreasonable trade. In brief, the main points of the study are as follows:

1. Although the dramatic qualities of the national airborne effort helped effect interstate educational cooperation, there is some question now about whether an airborne system three times its current size is required to maintain it or whether such co-operation could be maintained with a ground-based interconnection system.

2. Even if many problems associated with the reception of an airborne television signal could be resolved, the general difficulties surrounding such reception are a severe limitation to the use of these channels to a partial extent for schools that have already been involved in an added expense to receive signals, and completely for home use where MPATI does not propose to present any programs.

3. The program service proposed by MPATI indicates that roughly half the time is involved in replaying programs to provide

a more flexible schedule for use in schools. This is not actually a six-channel program service, and such program duplication hardly justifies the broad use of channels which the MPATI expansion would pre-empt.

4. Comments from schools supporting the proposed expansion do not indicate that schools are at all aware of the impact which airborne channel usage makes on the overall ground-based channel assignment in their areas. From the school point of view, the origin of television lessons is unrelated to their value, and school endorsement of the MPATI proposal is a support of televised instruction, not a declaration that airborne transmission should be the major supplier of these materials.

5. It is clear that less than one-fourth of the schools which are using the MPATI service are actually receiving the materials from the airplane transmission or an instantaneous relay of the broadcast. Of the 5400 member schools in the MPATI organization, 4200 of them lease video tapes of MPATI courses for use on local educational television stations.

6. Efficiency of geographic coverage is not positively correlated with educational efficiency and with efforts toward out-of-school and off-campus instruction. The fact that airborne transmission

is used only a portion of the week, during a portion of the day, that it is not easily received in the home, and that it effectively inhibits growth of land-based stations which could be used at all hours for a variety of purposes, cannot be considered any kind of useful efficiency.

7. The propagation curves proposed by the MPATI for ground-based stations are found to exhibit characteristics with regard to the extent of the service areas and the magnitude of signals available within the service area which have not yet been proved by field measurement. A more realistic estimate of these factors is provided by the propagation curves of the FCC rules.

8. Using a computer technique and interference standards proposed by the MPATI, it was learned that 46 channels in the Midwest area in the proposed NAEB UHF Assignment Table are displaced by MPATI airborne transmission.

9. Using the computer again, with interference standards developed by the NAEB, following FCC propagation curves, it was learned that 83 channel assignments in the Midwest area are displaced by the MPATI proposal.

10. Other technical considerations relating to the feasibility of operating six transmitters from two airplanes, ground-to-air signal transmission, lack of coverage directly beneath the aircraft,

ground reflected signal cancellation, translators in the metropolitan areas, alternate polarization of the transmitted signal, and the possibility of using the 2500-megacycle band for air-to-ground transmission are all unsettled and need much further clarification before regularized use of airborne transmission should be used.

On the basis of its studies, the National Association of Educational Broadcasters recommends the following:

1. To conserve local use of available channels and to preserve local control of education, television channels should be reserved for use by local authorities. The proposed alternative, whereby a large number of channels would be usurped by an airborne operation and put in the hands of a central authority serving only a small percentage of schools in the midwest area, is not acceptable.

2. It is recommended that no mass modification of FCC Rules regarding UHF Propagation and interference standards be made. Where unusual circumstances and careful engineering indicate that modification or waiver of these Rules would be in the public interest, exceptions should, of course, be made. At this time, however, the need for any complete revision of the Rules in this regard is not well justified.

3. If airborne television transmission is continued on a regular

or permanent basis for two channels, it is recommended that this service be maintained on a secondary basis and that these frequencies not be allowed to pre-empt the use of ground-based UHF assignments where they are requested and meet with the approval of the FCC.

4. It is recommended that much further study be given to the problem of distributing educational television materials. Most parties filing comment in these matters have assumed that only two alternatives exist to provide six-channel coverage to schools--a six-channel land-based system of UHF broadcast stations or a six-channel airborne system. In view of the small number of schools which actually receive MPATI programs directly from the airplane, it is felt that other means of interconnection among communities interested in participating in the MPATI service should be explored.

The experiment which has been conducted by the Midwest Program on Airborne Television Instruction has contributed important information about both technical and educational matters, particularly by discovering what can and cannot be done through educational co-operation and by developing a significant educational program production complex.

These efforts are the strength of the MPATI, and the airplane is its weakness. By investing its resources in additional educational

cooperation and distribution of specialized instructional material through other means, it is likely that the major contribution of this effort will have been its use of the airplane to lift the sights of educators beyond the school district lines. This is not a small contribution, and there is every reason to hope that it will be possible for an inter-state educational organization to continue its contribution without inhibiting the growth of a broader, more comprehensive, and more flexible land-based television system.